Combined Cycle Engine (CCE) Large Scale Inlet for Mode Transition Experiments (LIMX) Mode Transition Modeling and Control
Fundamental Aeronautics – Hypersonic Project

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NASA Glenn Research Center
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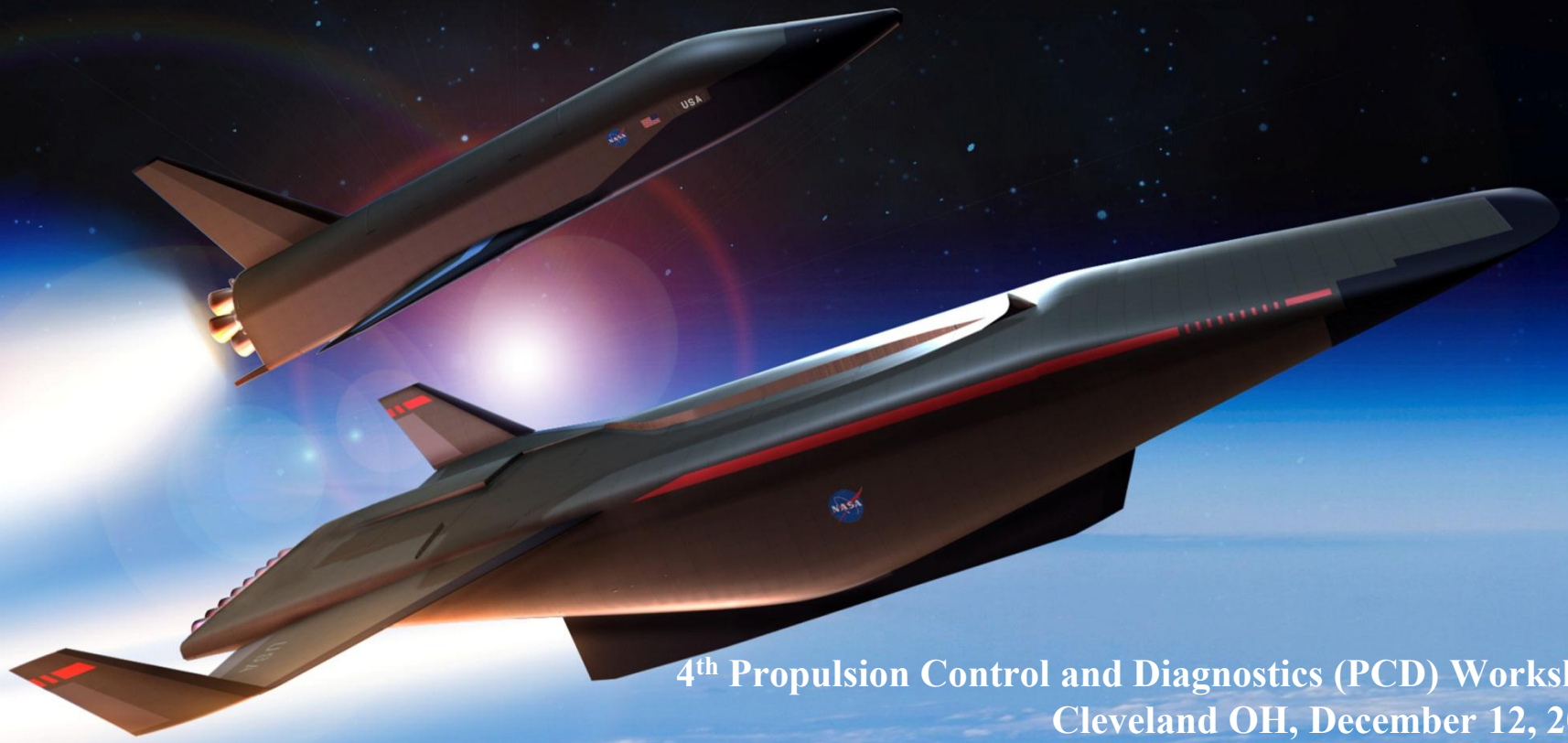
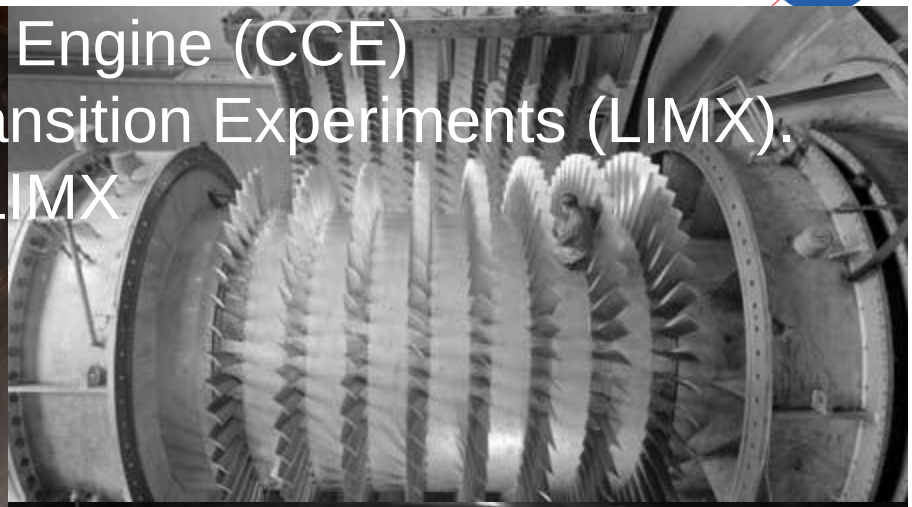
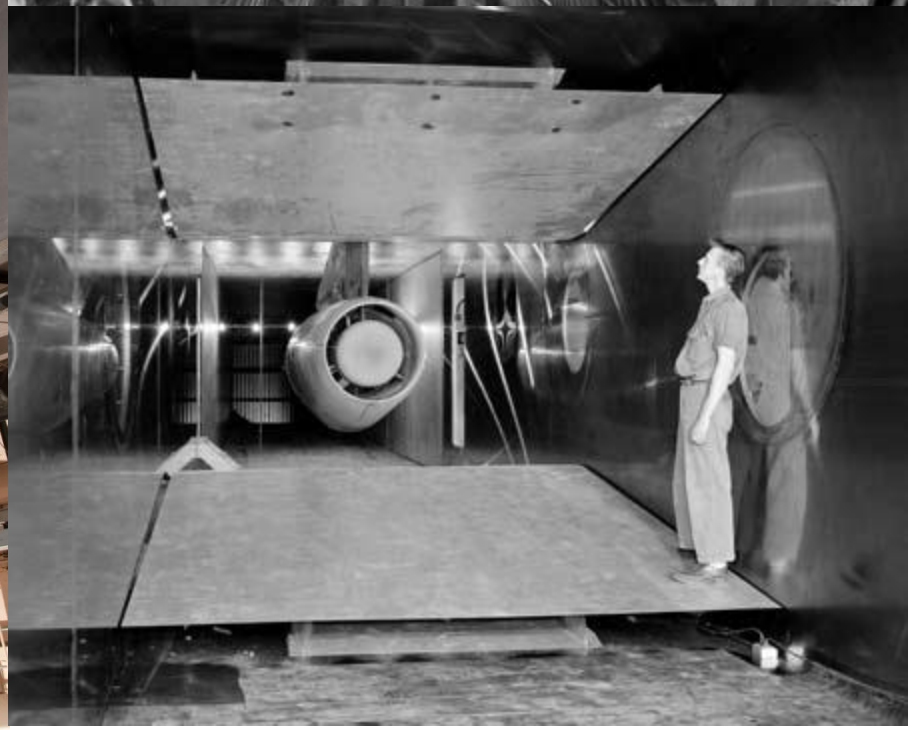


4th Propulsion Control and Diagnostics (PCD) Workshop
Cleveland OH, December 12, 2013

Combined Cycle Engine (CCE) Large-Scale Inlet for Mode Transition Experiments (LIMX). CCE-LIMX



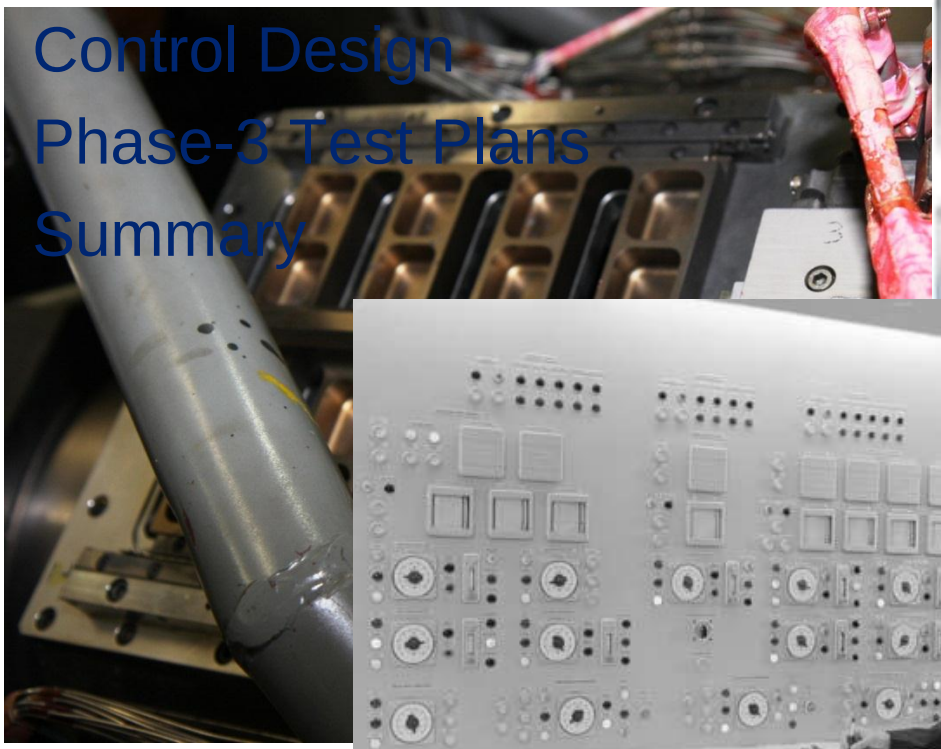


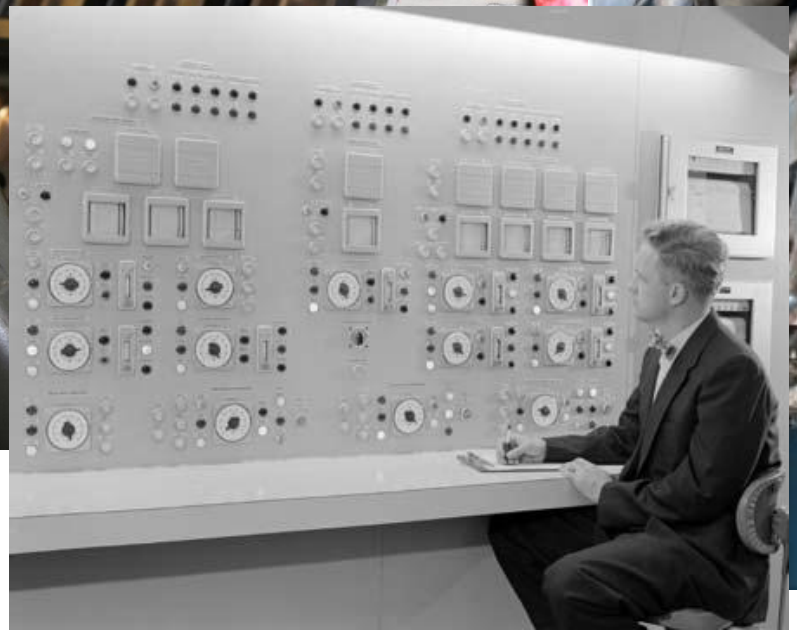
Team

- NASA GRC Research Directorate:
  - Communication, Instrumentation, and Controls Division
    - Controls and Dynamics Branch (RHC)
      - Jeffrey T. Csank, Thomas J. Stueber, Randy Thomas
    - Digital Communications and Navigation (RHD)
      - Joseph A. Downey, Jennifer M. Nappier, Binh V. Nguyen
  - Aeropropulsion Division
    - Inlet & Nozzle Branch (RTE)
      - David Davis, Lancert E. Foster, Dave Saunders, John W. Slater
- NASA GRC Engineering Directorate:
  - Systems Engineering and Analysis Division
    - Propulsion & Control Systems Engineering (DSS)
      - Dzu K. Le, Daniel R. Vrnak
- NASA GRC Facilities & Test Directorate:
  - Testing Division, Wind Tunnel & Propulsion Test Branch.
- Industry Partners
  - TechLand Research Inc. Bobby W. Sanders, Lois J. Weir
  - Spiritech Advanced Products Inc., Eric J. Gamble, Dan Haid, Sal D'Alessandro, Rich DeFrancesco.

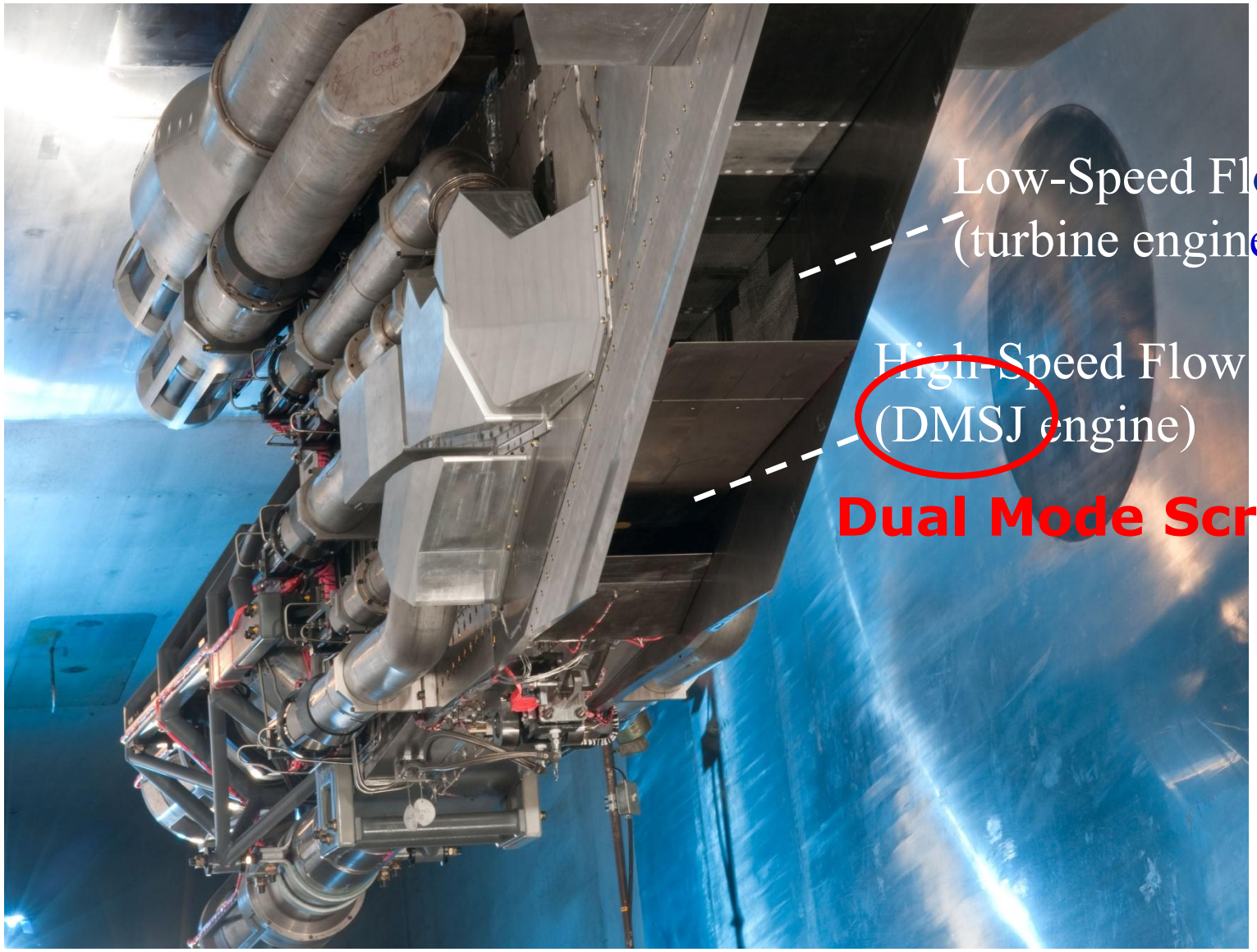
Outline

- Overview of CCE-LIMX Inlet System
- Control Affecters
- Control Design
- Phase-3 Test Plans
- Summary

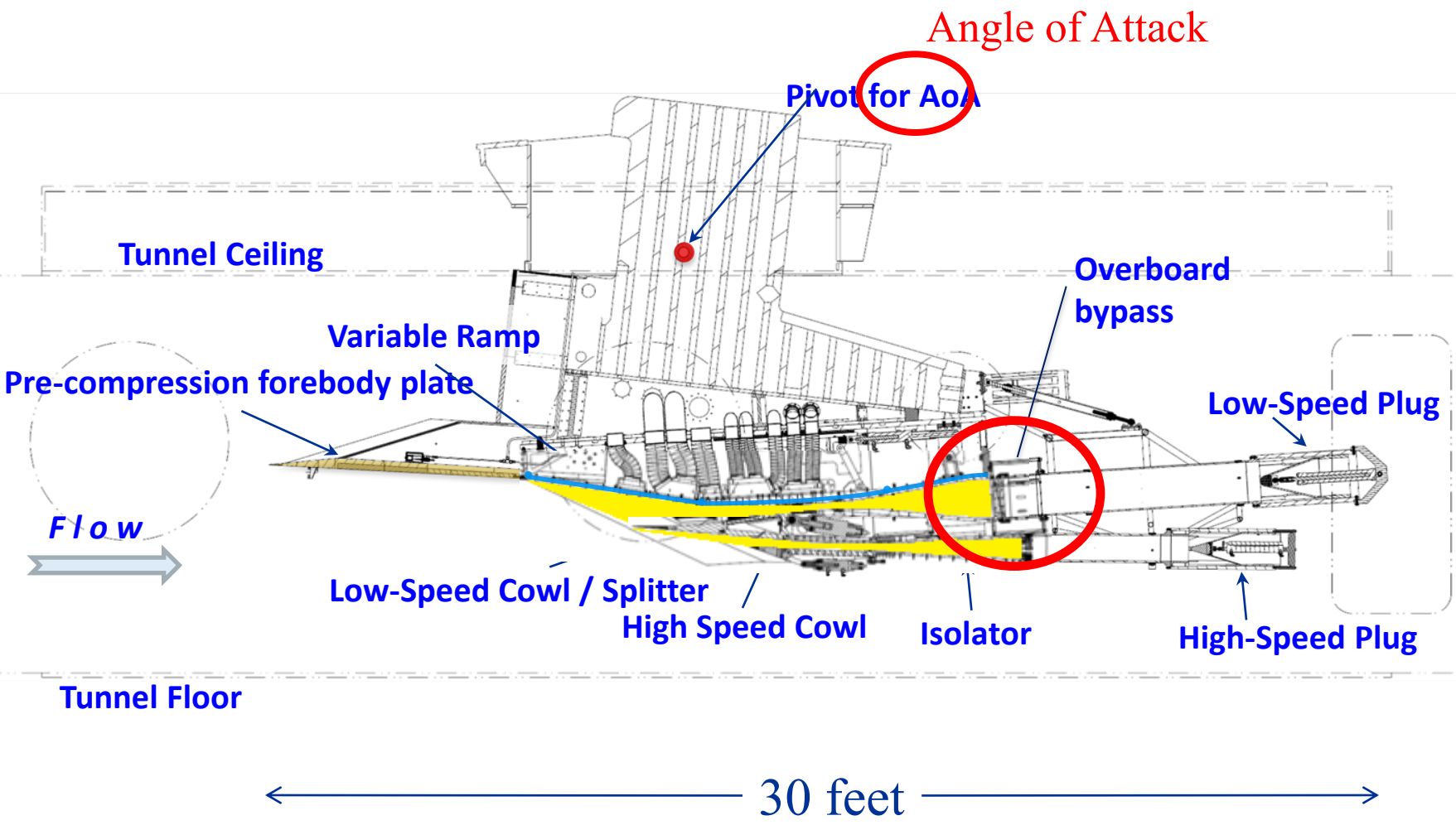




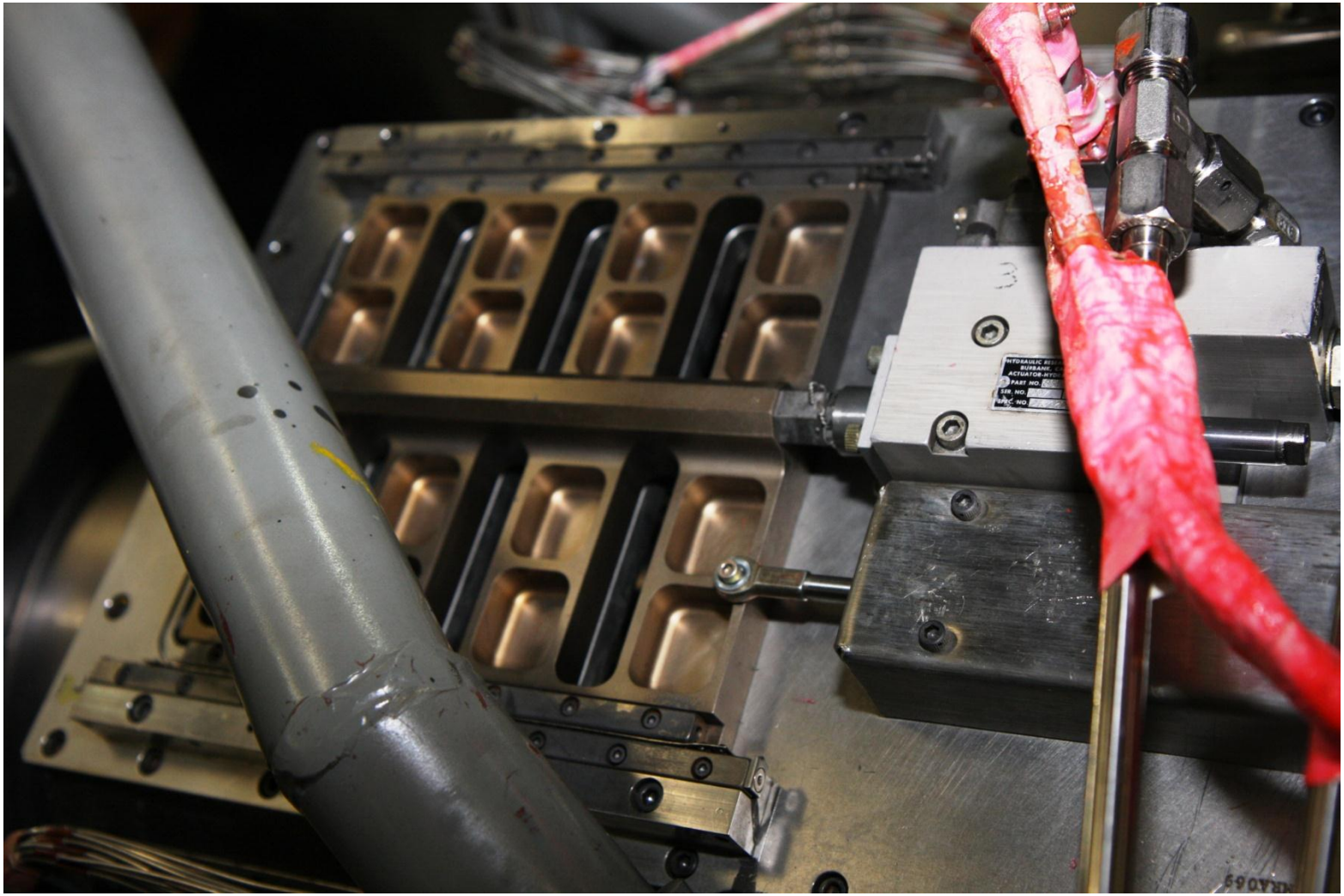
CCE-LIMX Model



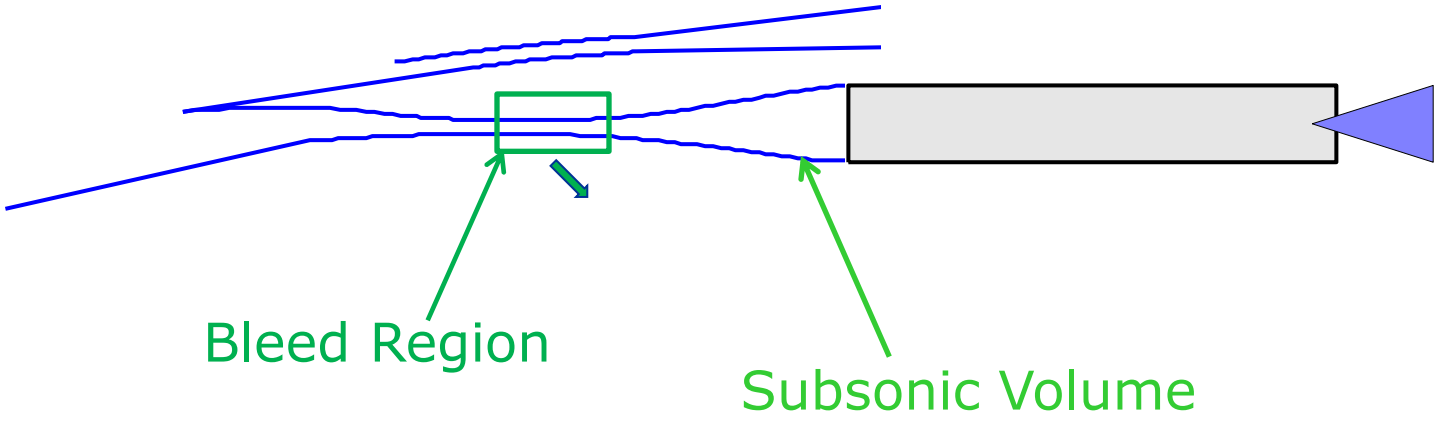
CCE-LIMX Model Features



Control Affecters



Phase 1: Inlet Characterization and Performance Testing



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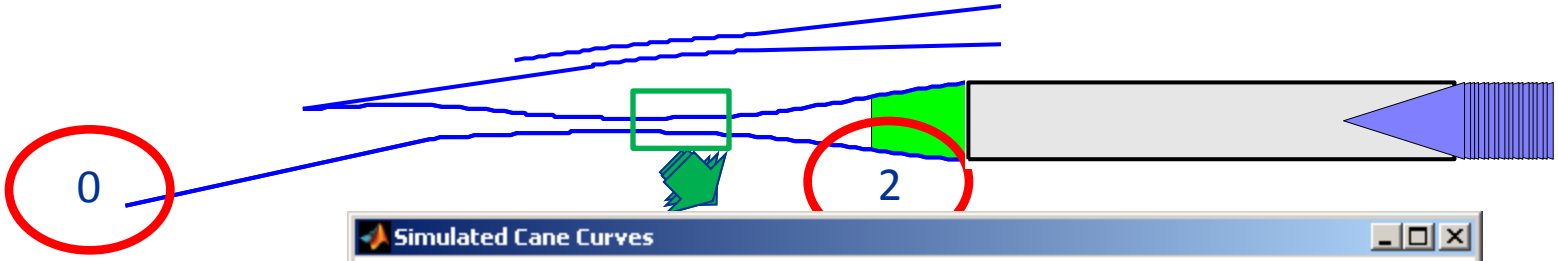

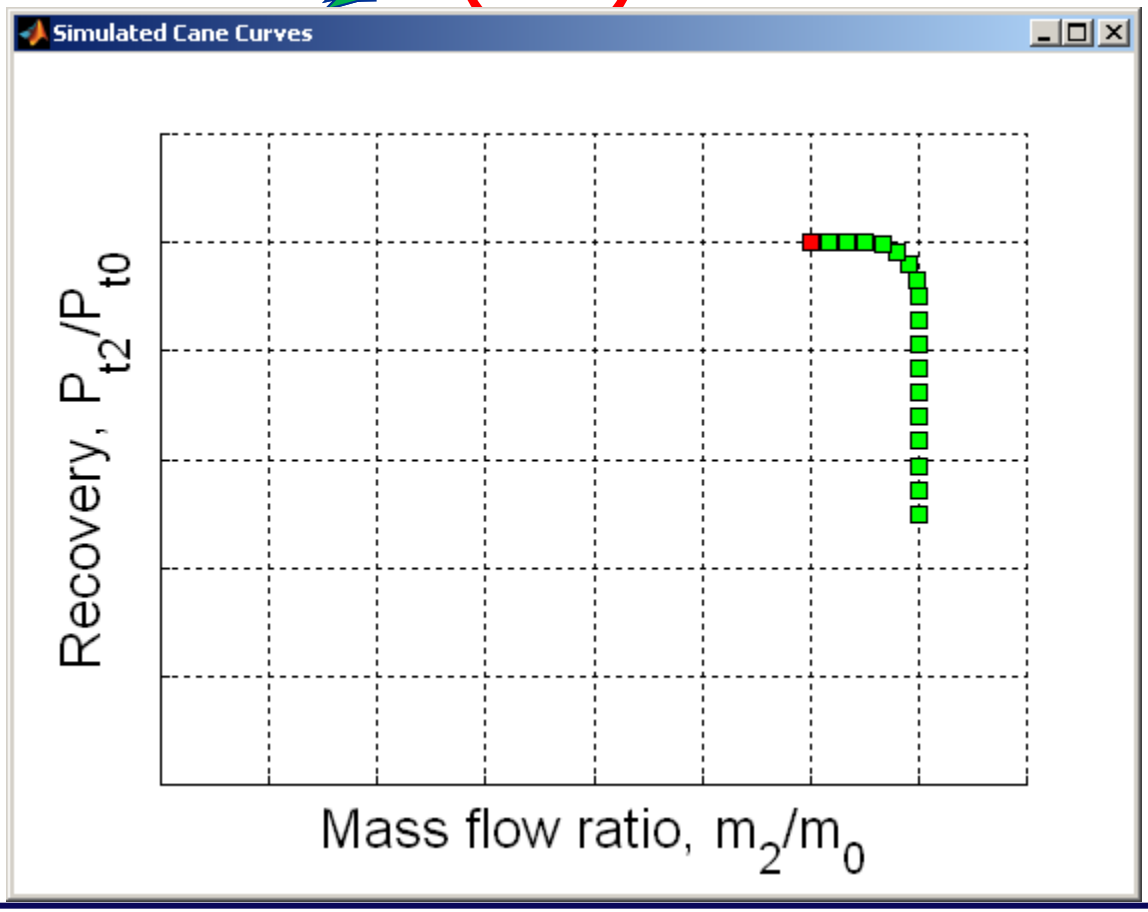

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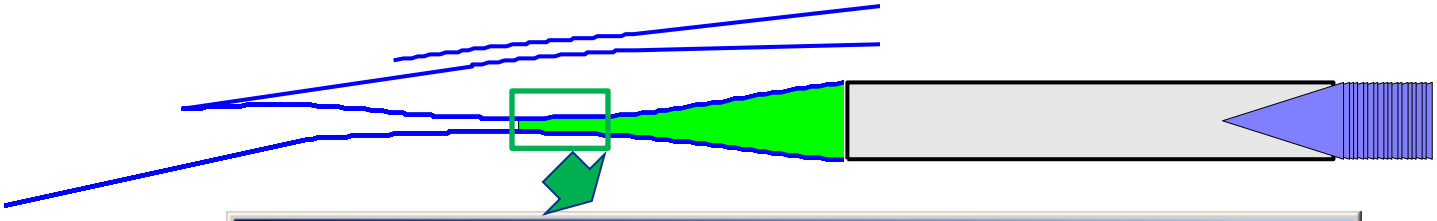

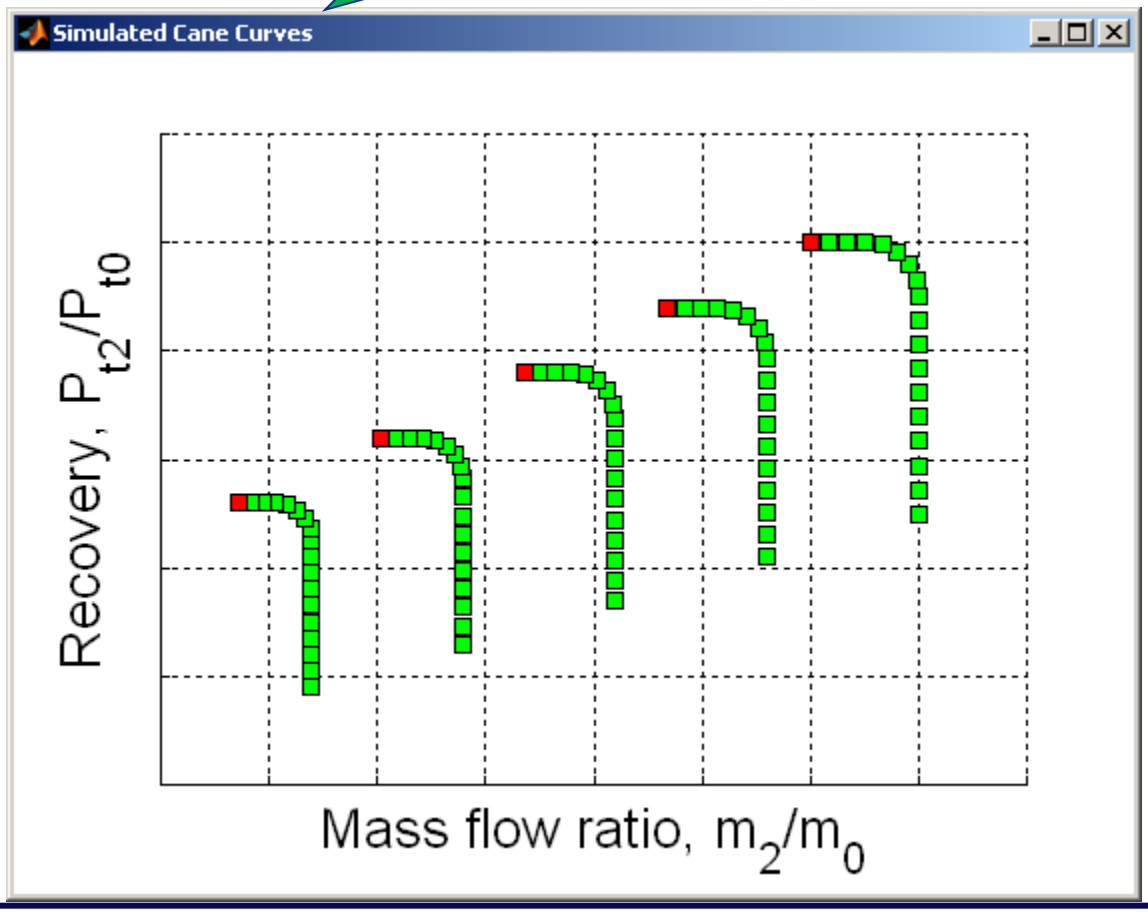

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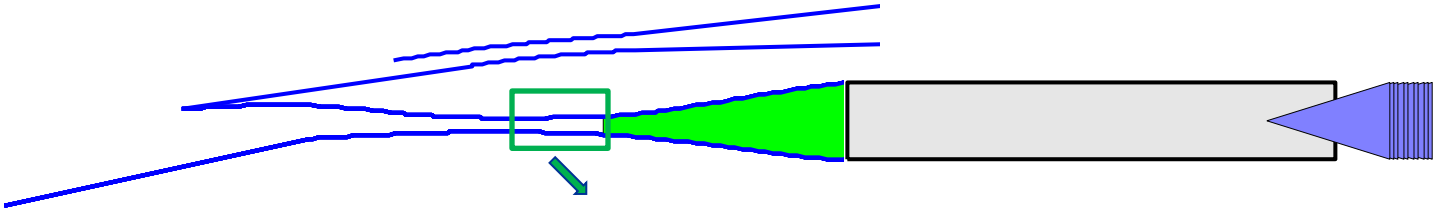
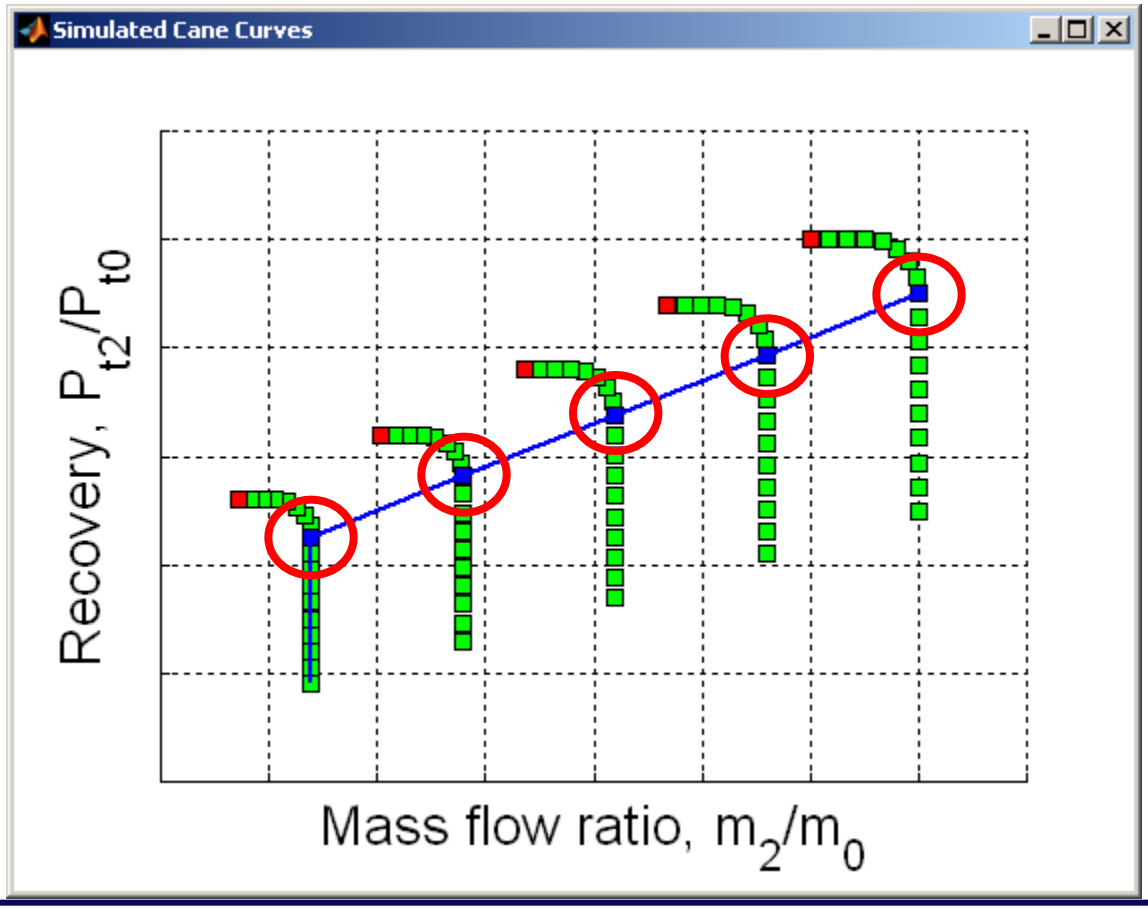
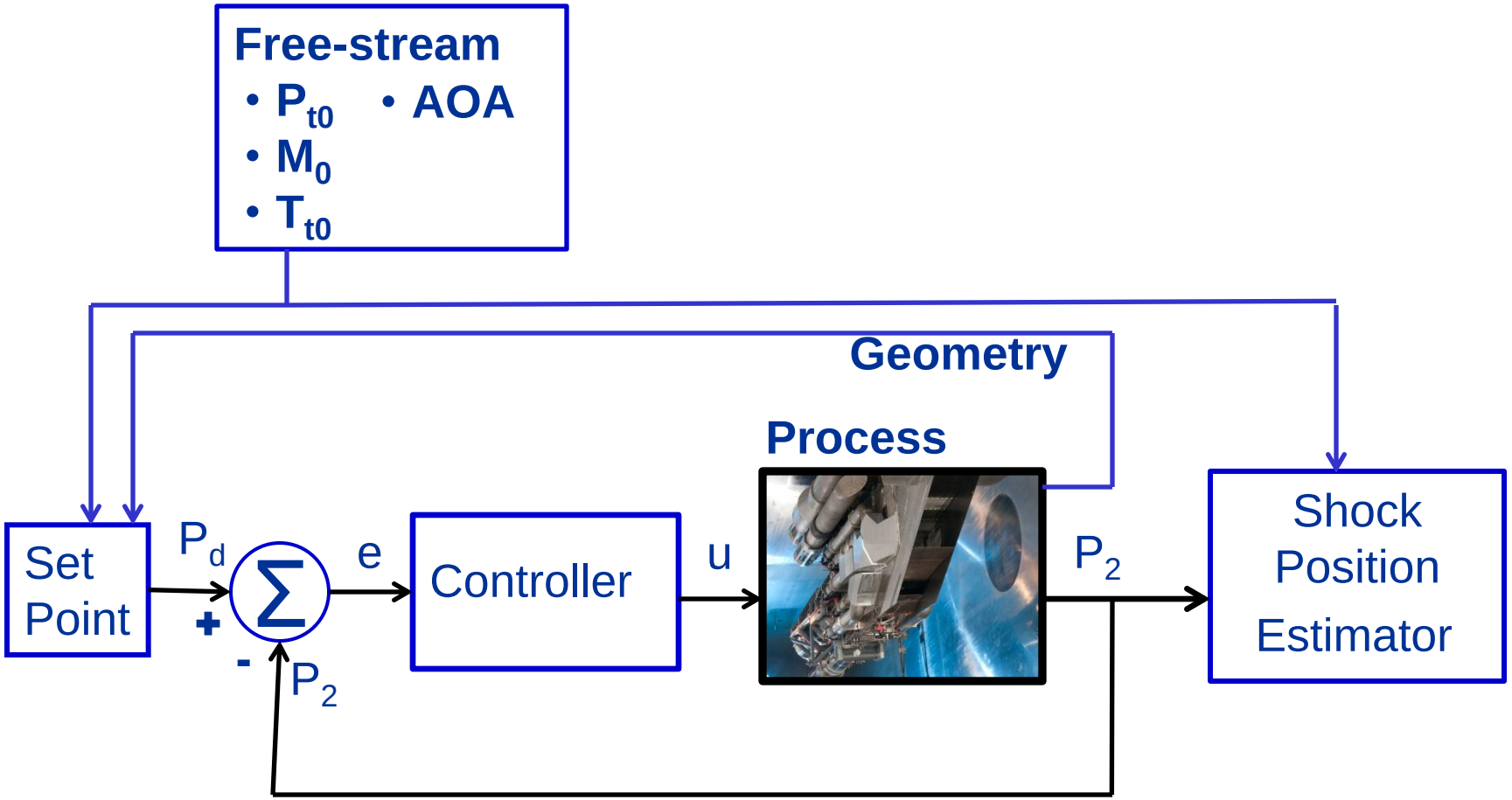




Control Design



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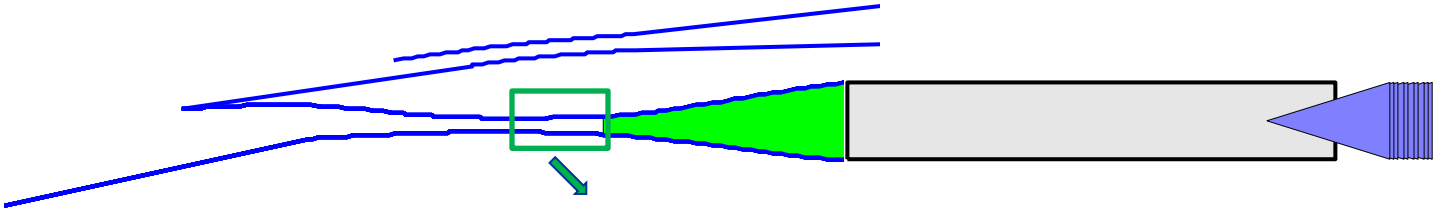

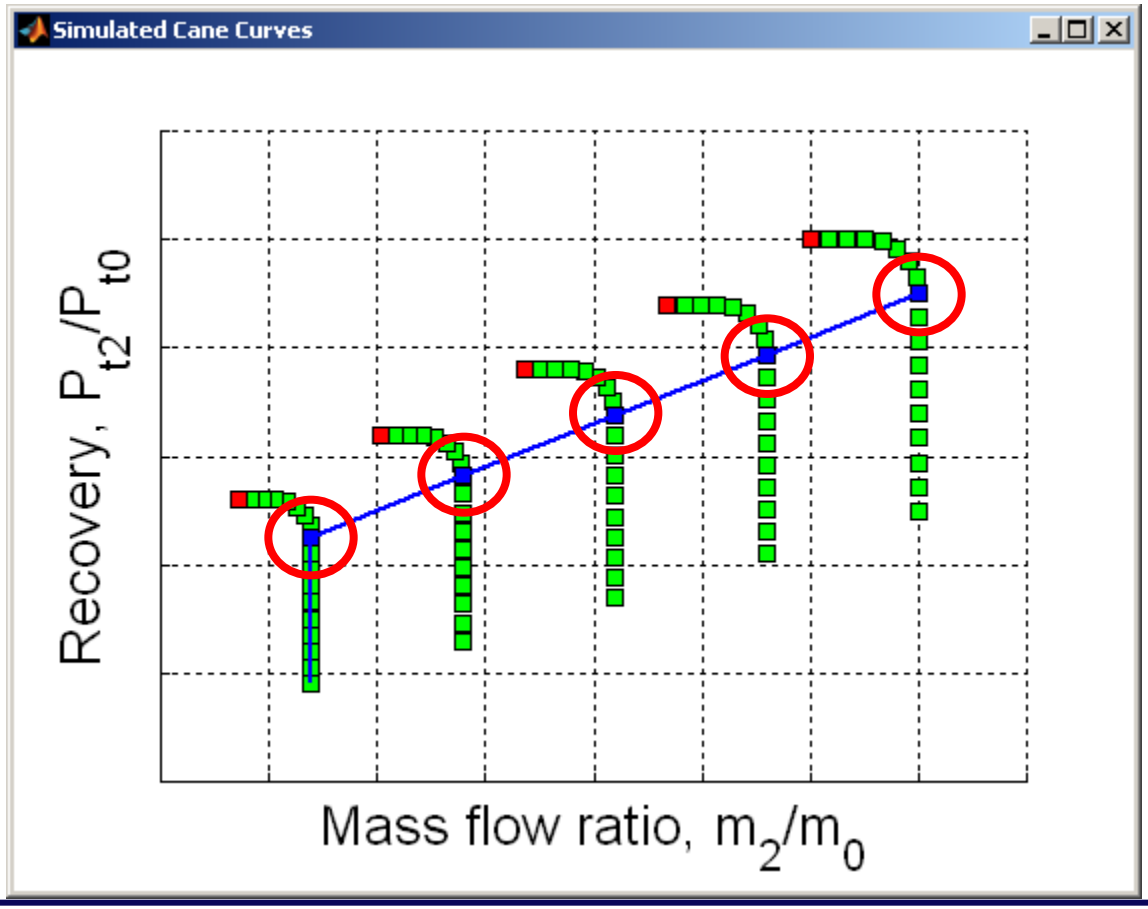

Phase 2 Accomplishments

- Test matrix status Phase 2 Mach 4
  - 642 experiments identified, ~89 hrs
    - Main (LST1 and HST1) schedule—506 experiments, ~49 hrs
    - First alternate (LST1 and HST2) schedule—68 experiments, ~20 hrs
    - Second alternate (LST2 and HST2) schedule—68 experiments, ~20 hrs
  - Reduced matrix—393 experiments selected, ~29 hrs
    - Main schedule—378 experiments completed, 38.25 hrs
    - Alternates—0 experiments completed
  - Experiments:
    - Step, Sinusoidal-Sweep, Sustained-Sinusoid
    - Staircase, Transient Stability Index (S_{it}),
    - Unstart, Buzz, Restart
- Test window: 8/29/2011 – 10/19/2011
- 11 run nights (data collection)

Phase-3 Plans

- Open-Loop mode transition along schedule
  - Transient stability index at operating points on schedule
- Closed-Loop mode transition along schedules
  - Perturbation testing at each operating point:
    - Step change
    - Sinusoidal sweep
    - Sinusoid pulse
  - Perturbation testing during closed-loop mode transition.

Summary

- Combined Cycle Engine (CCE) Large Scale Inlet for Mode Transition Experiments (LIMX)
  - Designed,
  - Built,
  - Installed in NASA GRC 10- x 10-foot SWT
  - Completed Phase-1 and Phase-2 testing
  - Preparing for Phase-3 testing.

Questions?